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Research on food losses and waste in North Africa

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ABSTRACT

Background: Food losses and food waste represent an emerging problem with enormous economic, environmental, and social implications. Therefore, the reduction of food wastage is considered a promising strategy, not only to achieve food security but also to improve the food system sustainability. Food wastage is a serious issue also in North Africa region. **Aims:** This paper provides an overview on research dealing with food losses and waste (FLW) in North Africa (Algeria, Egypt, Libya, Mauritania, Morocco and Tunisia). **Methods and Material:** A systematic review was carried out in January 2018 using Scopus database. Issues addressed in the systematic review include geography of research on FLW in North Africa (i.e. countries considered or underserved), bibliometric parameters (e.g. journals, institutions) as well as thematic focus (agricultural loss, food waste). Selected records were also interrogated to see if they address the extent of FLW, the relation between food wastage and food security, economic implications of FLW, and environmental footprints of FLW. **Results:** The results show that research on FLW is still marginal in North Africa in general and in Libya and Mauritania in particular. Moreover, while there are some interesting pieces of research on the amount of FLW, environmental and economic impacts of FLW as well as their implications in terms of food security are largely overlooked. **Conclusions:** Therefore, North African researchers should pay more attention to food wastage issue. Such an endeavor should be supported by research policy in North Africa.

Keywords: Agricultural losses, Environment, Food losses, Food security, Food wastage, Food waste, North Africa.

1 Introduction

Food losses and waste (FLW) represent an emerging problem with enormous economic, environmental and social implications [1]. Food waste is one of the most severe social, economic, and ecological pathologies among those facing the planet [2]. The High Level Panel of Experts on Food Security and Nutrition (HLPE) defines food losses and waste as "a decrease, at all stages of the food chain from harvest to consumption, in mass, of food that was originally intended for human consumption, regardless of the cause" [1] (p. 22). FLW occur between the moment when a product is ready to be harvested or harvested, and the moment when it is consumed or removed from the food supply chain. Food losses take place at the production, post-harvest and processing stages in the food supply chain. Losses occurring at the end of the food chain (retail and consumption) are referred to as 'food waste' [1,3,4].

Today, about four billion metric tons of food are produced per annum worldwide. However, due to poor practices along the food chain (harvesting, storage and transportation), as well as market and consumer wastage, it is estimated that 1.2–2 billion tons of all food produced never reaches a human stomach [1,4]. There are considerable variations from one country, commodity, and season to another [5]. In developing countries, 40% of losses occurs at post-harvest and processing levels, while in industrialized countries more than 40% of losses happens at retail and consumer levels [1,4].

In addition to general lack of data on food losses and waste [6], there are many inconsistencies [7]. This is, at least partly, attributable to the use in English of the term 'waste' both to refer to 'wastage/squander' and 'garbage/trash/rubbish'. Therefore, more focused terms such as 'food wastage' [e.g. 8] or 'waste of food' [9] have appeared recently. The term 'food wastage' encompasses both food loss and food waste [8].

FLW undermine the very foundations of food and nutrition security. Therefore, the reduction of the amount of food lost or wasted is now presented as essential to achieve food security [1,10,11-13] and improve the sustainability of the current food system [1]. When converted into calories, global FLW amount to approximately 24% of all food produced. Essentially, one out of every four food calories intended for people is not ultimately consumed by them [14-16]. Even if just one-fourth of the food currently lost or wasted globally could be saved, it would be enough to feed 870 million hungry people [17]. The world's nearly one billion hungry people could be fed on less than a quarter of the food that is wasted in the US and Europe [18]. Food wastage represents also a loss of valuable nutrients (both macro- and micro-nutrients) [19].

Nowadays, FLW reduction is also considered as essential to reduce the environmental footprint of food systems [11,13,15,20-24]. In fact, this is presented as crucial for reducing the emission of greenhouse gases (GHG), thus slowing down the pace of climate change, and des-intensifying natural resources use. Food loss and wastage amount to major squandering of resources, including water, land, energy, labor and capital [4,17]. FLW can be translated into direct and indirect environmental impacts. They have two major direct environmental impacts: waste of the resources used to produce the food lost and wasted, and a major source of negative impacts, including emissions of GHG at disposal. Indirect environmental externalities include unnecessary water pollution caused by the intensive use of fertilizers in agriculture. FLW negative externalities also include those that mono-cropping and agriculture expansion into wild areas (e.g. forests) create in terms of biodiversity loss [8]. FAO [8] showed that footprints of FLW include carbon footprint (greenhouse gas emissions), water footprint (consumption of surface and groundwater resources), ecological footprint (agricultural land use) as well as indirect impacts and externalities on biodiversity.

In addition, food wastage implies a considerable loss of money for both producers and consumers [1, 2,4]. In fact, FLW represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses [14] as food losses translate into lost income for farmers and into higher food prices for consumers [1,17,13].

Food wastage is a serious problem also in the Near East and North Africa (NENA) region. FLW in the NENA region are high [25-27] and contribute to reduced food availability, aggravated water scarcity, adverse environmental impacts and increased food imports in a highly import-dependent region [25,27]. It is estimated that 34% of food supplies suitable for human consumption are being lost or wasted in NENA region [4]. Generally speaking, only about 32% of FLW in North Africa and West and Central Asia (cf. NENA region) occurs at the consumption stage (mostly in urban centers), while up to 68% of FLW occur during production, handling, processing and distribution [25]. Quantitative FLW in NENA region are estimated to be 45% of fruits and vegetables, 28% of fish and seafood, 26% of roots and tubers, 18% of dairy products, 16% of oilseeds and pulses, 14 to 19% of grains and 13% of meats [25,26]. Not only food losses but also food waste, including household food waste, is a critical issue in NENA countries [e.g. 27-32]. However, all figures on FLW in NENA reported above are only estimates as accurate data on the magnitude, causes and stages of FLW in the region have not been systematically collected and included in national or international databases [26].

The present paper sheds light on research dealing with food wastage in North African countries namely Algeria, Egypt, Libya, Mauritania, Morocco, and Tunisia.

2 Subjects and Methods

A systematic review [31] was carried out in January 2018 using Scopus database, as shown on Figure 1. The use of Title-Abs-Key search query – (food OR agri*) AND (wastage OR waste OR loss) AND (Algeria OR Egypt OR Libya OR Mauritania OR Morocco OR Tunisia) - yielded 980 documents. Following a deep scrutiny of titles, 883 documents were not considered for further analysis as they do not deal with food wastage in North Africa. In particular, documents that deal with sanitation, wastewater (cf. olive oil wastewater) and use of animal/agricultural waste as soil amendment/conditioner were excluded.

Further 49 documents were excluded based on analysis of abstracts. At this step, were left out records that deal only with the reuse or recycling of by-products and ‘unavoidable food waste’ [e.g. 32,33], that is to say non-edible agricultural and animal products parts that are, anyway, unsuitable for human consumption (e.g. date stones, shells, peels, animal bones or skin). Likewise, documents that address only the use of agricultural waste for the production of energy or as raw material for building industry or animal feed were discarded. Furthermore, records that deal with non-food crops (e.g. cotton, ornamental plants) were not considered. Additional 29 documents were excluded after scrutiny of full texts.

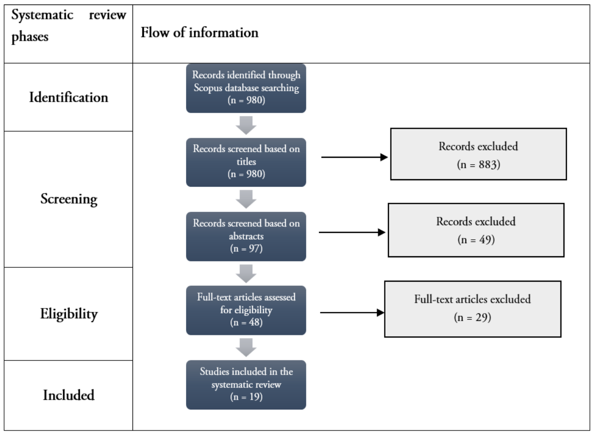
Systematic review phases
Flow of information
Identification
Screening
Eligibility
Included
Records identified through Scopus database searching (n = 980)
Records screened based on titles (n = 980)
Records excluded (n = 883)
Records screened based on abstracts (n = 97)
Records excluded (n = 49)
Full-text articles assessed for eligibility (n = 48)
Full-text articles excluded (n = 29)
Studies included in the systematic review (n = 19)

Figure1: Flow chart of studies review

Therefore, only 19 records (Table 1) were included in the systematic review and underwent a deeper analysis.

Table 1: Records considered in the systematic review on research dealing with food losses and waste in North Africa

Year	Number of records	References
2018	1	Abdelradi [34]
2017	1	Haouel Hamdi et al. [35]
2016	1	Shreen et al. [36]
2015	1	Trabelsi et al. [37]
2013	3	Helmy et al. [38]; Padilla [39]; Rady & Soliman [40]
2012	1	Qaryouti et al. [41]
2011	1	Kandil et al. [42]
2010	1	Harrak & Jaouan [43]
2006	1	El-Mobaidh et al. [44]
2000	2	Benkeblia [45]; Sharobeem & Radwan [46]
1996	2	Hussein et al. [47]; Hussein et al. [48]
1995	1	Fuglie [49]
1994	1	Bansal et al. [50]
1992	1	Bansal & Sakr [51]
1990	1	Fouad et al. [52]

Both issues regarding metrics and topical focus of research on FLW in North Africa were addressed in the analysis (Table 2).

Table 2: Issues and topics addressed in the systematic review

Topic	Elements considered
Metrics and geography of research on food wastage in North Africa	- Metrics: year of publication, source/journal, institution/affiliation, subject area - Geography of research: North African countries considered or underserved
Topical focus of research on FLW in North African countries	- Thematic focus (agricultural loss or food waste) - Extent of food losses and food waste - Food wastage and food security - Economic implications of food wastage - Environmental implications of FLW (carbon footprint; water footprint; ecological footprint; other environmental impacts such as deforestation, biodiversity loss and ecosystems disturbance)

3 Results and Discussion

3.1 Marginality of research on food losses and waste in North Africa

The main finding of the present systematic review is the marginality of research on FLW in North African countries (i.e. Algeria, Egypt, Libya, Mauritania, Morocco and Tunisia). In fact, a search with Title-Abs-Key query (food OR agri*) AND (wastage OR waste OR loss) (so, without limiting the search to North Africa) yielded 5600 documents; that is about 6 times the number of records yielded with the search on food wastage in North Africa. It is even worse when one considers that only 19 documents resulted dealing effectively with food wastage in North Africa. This result is rather surprising given the extent and magnitude of food wastage problem in the region. In fact, the 31st FAO regional conference in the Near East (FAO NERC-31, May 2012) recommended FAO to assist member countries in addressing the key challenges of reducing food waste and losses by conducting comprehensive studies on impact of food losses and waste on food security in the region and in establishing a plan to reduce food losses and waste in the region by 50% within 10 years” [26]. Probably, it is for this reason – i.e. awareness of the lack of studies on extent, origins, causes, and nature of FLW - that the Regional Strategic Framework on ‘Reducing Food Losses and Waste in the Near East & North Africa Region’ dedicated one of its four components to ‘Data gathering, analytical research and knowledge generation’ [26]. The need of further research on the issue of food wastage in North

Africa was also highlighted by many other scholars [e.g. 34].

3.2 Metrics of research on food wastage in North Africa

Metrics (sources / journals, affiliations / institutions, countries, subject areas) of research dealing with food wastage in North Africa are reported in Table 3.

The output of papers per year ranged from three (2013) to none in some years (e.g. 2014, 2009, 2008, 2007, 2005, 2003). Most of selected articles were published on *Acta Horticulturae*. Of course, there is a relation between subject areas and journals, so that it comes no surprise that most of the selected papers are related to the subject area of 'Agricultural and Biological Sciences'. However, selected papers can be categorized in many subject areas, which may explain difficulty to grasp the research field of food wastage, as it is rather multidisciplinary.

There are huge inter-country differences. In fact, it seems that Egypt performs better in research on food wastage than the other North African countries (Morocco, Tunisia, Algeria). However, one should consider with caution such a statement, as it does not take into consideration the different sizes of these countries and, consequently, their research systems (cf. research performance of North African countries on Elsevier's SciVal using as indicator the number of scientific articles per million inhabitants). Meanwhile, it seems that no research institution in Mauritania and Libya published papers on food wastage. Research on food wastage in North Africa is performed also by other institutions outside the region (e.g. USA, France). Also the affiliations are dominated by Egyptian research institutions such as the Agricultural Research Center and Alexandria University.

3.3 Topical focus of research on food losses and waste in North African countries

Most of the selected documents deal with agricultural loss while food wastage in distribution and consumption is underserved. It should also be highlighted that while interest in agricultural losses (especially their causes) dates back to many decades, the focus on food waste is rather recent in North Africa. It is also surprising that no paper refers explicitly to agricultural 'loss' (or losses) in the title. Meanwhile, only one article does so in the case of food 'waste' [e.g. 34], with a particular reference to food waste behavior at household level in the metropolitan area of Cairo.

As for the extent of food losses and food waste, many papers analyzed the magnitude of food losses especially at harvest (e.g. due to traditional harvesting and the impact of using improved and modern harvesting machines [35-39]), during post-harvest / storage (e.g. because of some pests [40]), but also inappropriate storage conditions [41-44], handling [45] or in processing [46]. Kandil et al. [47] highlighted that onion losses during storage depend on field agronomic management especially irrigation and mineral fertilization. According to Benkeblia [44], storage losses in Algeria range from 15 to 40% (in hot weather conditions) for potatoes, from 20 to 50% for onions (because of rotting and sprouting), from 10 to 20% for dates (because of insect infestation). In general, these analyses are context- and product-specific

Table 3: Metrics of research on food wastage in North Africa

Journal (*)	Subject area (**)	Affiliation / Institution (***)	Country (****)
Acta Horticulturae (5)	Agricultural and Biological Sciences (14)	Agricultural Research Center (3)	Egypt (11)
AMA Agricultural Mechanization in Asia Africa and Latin America (2)	Engineering (5)	Alexandria University (3)	Morocco (4)
Applied Engineering in Agriculture (2)	Environmental Science (3)	High Institute Agricultural Cooperation, Egypt (2)	United States (3)
Waste Management (2)	Chemical Engineering (2)	Institut National de la Recherche Agronomique de Tunisie (2)	Algeria (2)
Acta Agronomica Hungarica (1)	Earth and Planetary Sciences (1)	Universite de Carthage, Tunisia (2)	Tunisia (2)
Agricultural Engineering International CIGR Journal (1)	Economics, Econometrics and Finance (1)	Centre Regional de la Recherche Agronomique, Morocco (1)	France (1)
American Journal of Agricultural Economics (1)	Energy (1)	Kafrelsheikh University, Egypt (1)	Israel (1)
Chilean Journal of Agricultural Research (1)	--	National Center for Agricultural Research and Extension (NCARE), Jordan (1)	Jordan (1)
International Agrophysics (1)	--	CIHEAM-IAMM, France (1)	Palestine (1)
Journal of Asia Pacific Entomology (1)	--	International Center for Agricultural Research in the Dry Areas – ICARDA, Morocco (1)	Romania (1)

Legend: Figures in brackets refer to number of documents by (*) Journal; (**) Subject area; (***) Affiliation; (****) Country.

(e.g. chickpeas and lentils in Morocco; rice in Egypt; potatoes in Tunisia; chickpea in Tunisia; peanut in Egypt; cucumber, pepper and beans in Egypt; onion in Egypt).

There is in the selected documents no comprehensive analysis of the extent of food wastage in distribution and consumption in North Africa. Nevertheless, Abdelradi [34] showed that perception about food wastage was affected by quantities of household food waste. El-Mobaidh [48] classified in-flight catering wastes in Egypt Air flights and found that food waste represents 23% to 51.2% of total waste, depending on meal type; this corresponds to 284 tons per year in Egypt Air flights.

The relation between food waste and food and nutrition security is not directly addressed in the selected papers. However, many documents point out to the impacts of losses on yields and food supply [e.g. 36-38,40,49], so, indirectly, on food security. Some articles also referred to 'qualitative losses' (loss of nutritional value of products, see vitamins, micronutrients, etc.) [e.g. 40,50] and these results connect food losses with nutrition and nutrition security in North African countries. In fact, Haouel Hamdi et al. [40] showed a decrease of the nutritional value of chickpea seeds infested by beetles. Padilla [51] pointed out that ambient temperature can alter nutrients during tomato processing.

Once again, only some papers dealt directly with the economic implications of food wastage. In fact, some documents analyzed the implications of agricultural losses in terms of yield reduction, and this implies also economic losses for farmers. No paper analyzed the effects of food waste on consumer prices of agricultural products in North Africa. However, Fuglie [52] referred to benefits for producers and consumers from the reduction of potatoes storage losses in Tunisia. Similarly, Haouel Hamdi et al. [40] refer to economic losses due to damage of beetles on chickpea seeds and flour in Tunisia. Abdelradi [34] found that food price is among the major factors explaining food waste behavior at household level in Cairo metropolitan area.

As for the environmental implications of food losses and waste, there has been no analysis of the impacts of food wastage in terms of carbon footprint (energy losses and greenhouse gas emissions), water footprint and ecological footprint (land occupation and degradation). Moreover, selected papers address neither the relation between food wastage and climate change nor the indirect impacts of food wastage such as pollution of underground and surface water resources as well as deforestation, biodiversity loss and ecosystems disturbance. Nevertheless, Abdelradi [34] highlighted the need to increase consumers' knowledge and awareness about environmental implications of food wastage.

4 Conclusion

To the best of our knowledge, this is the first paper to make a systematic review of research on food losses and waste in North Africa. It clearly shows the marginality of research on food wastage in the region. Although some interesting and promising activities have been carried out over last years, research is rather fragmented and still at an embryonal stage of development. In other words, research on food wastage in North Africa has still a long way to go in order to reach levels comparable to those in Europe. Therefore, more attention should be paid to the issue of food losses and waste in the research policies and strategies of North African countries.

It is also recommended to have a better collaboration between research teams in these countries. This is of paramount importance given the enormous environmental, economic and social impacts of food wastage as well as its implications in terms of food security and food system sustainability (environmental, social, economic) in North Africa.

It should be pointed out that the use of a single database (i.e. Scopus) might have omitted some other relevant articles published on journals that are not indexed in Scopus. The use of Scopus also means that the article focuses only on peer reviewed scientific literature, not grey literature (e.g. reports). Therefore, there is a need of a broader coverage of the literature in order to have a clearer picture about the contours of research on food losses and food waste in North Africa.

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